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Waste Identification in Production Line of a Selected Ready Made Garment Industry Using Lean Concept in Bangladesh

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Abstract: *The ready-made garment (RMG) industry in Bangladesh is now enjoying the status of being the largest garment exporter and the largest exporter of knit garment to the European Union. The competition with other countries like China and India in Asia is not only on the basis of productivity but also on the basis of quality. That is why it needs continuous monitoring and improvement for mass production by reducing or eliminating any kinds of waste like over processing, excess motion, work in process inventory, transportation, waiting on production floor. Most of the garment industries of Bangladesh have been facing the problem of low productivity because of these wastes. So in this paper, a research has been made for identifying the dominating causes of waste and the quantitative measure of its influence on productivity by using the quality tools histogram, cause-effect diagram and process flow chart. By applying these tools it is possible to increase productivity as well as the efficiency of production line.*

Keywords: *Excess Motion, Inventory, Over Processing, Productivity, Transportation*

I. INTRODUCTION

The spectacular growth of garment sector in Bangladesh in recent years has dramatically changed the landscape of export composition of the country. Once heavily dependent on exports of primary products lead by Jute, the economy of Bangladesh is now experiencing almost 76% [1] export contribution from Readymade garments (RMG). The sector has now occupied an important place in our national economy. With the blessings of cheap labor, pressure for globalization of production based on location economies as well as the favorable treatment from developed countries, Bangladesh and some other developing countries have gradually become the global players in international trade in RMG. However, the Multi-fiber Arrangement facility, which was extended to favor the least, developed countries in exporting garments and textile has phased out after 2005. Consequently, the beneficiaries of MFA, including Bangladesh are facing severe competition in the unprotected world market. At present, this sector is facing numerous challenges nationally and globally.

The competition with other countries like China and India in Asia is not only on the basis of productivity but also on the basis of quality. That is why it needs continuous monitoring and improvement for mass production by reducing or eliminating any kinds of waste like over processing, excess motion, work in process inventory, transportation, waiting on production floor. Most of the garment industries of Bangladesh have been facing the problem of low productivity because of these wastes.

To survive in this sector Bangladesh must take immediate pragmatic policies enabling itself to compete more efficiently in the changing business environment through minimization of waste.

Therefore it appears that in the present situation Bangladesh RMG industry will not be able to compete successfully in the international market for the existence of unusually waste management. This is specifically the main problem area of present research. To compete successfully in the fiercely competitive post-MFA global free trade market, the manufacturers must be adequately equipped with the latest knowledge of scientific management in minimizing lead time and other management deficiencies [2].

We have to give all out support to this sector and have to build up the backward linkage industry to reduce the dependence on imported raw materials and to minimize waste. Therefore, we need to find out some alternative ways to reduce or minimize the waste on production line. Here in this study steps also will be taken to focus on the waste management by presenting some successful and unsuccessful operations in the waste management process. The purpose of the present study is about analyzing the existing situation specially the waste management on sewing section in the RMG sector of Bangladesh.

II. DATA COLLECTION AND ANALYSIS

This section presents the findings of the case study. This case study has been conducted in a selected garments industry. This case study deals with various types of waste exists in sewing section more specifically time waste. The information as well as data has been gathered through the observation. The data and information was collected through the observation of the production floor and some past record from the industrial engineering of the selected industry. Finally all data has been analyzed by using various types of tables, graphs and some tools such as cause effect diagram, Histogram, process flowchart and time and motion study.

2.1 Over Processing

Rework items are detected in three sections in every production line.

1. **Front Inspection Section:** Front portion of the product is inspected and the data of rework is collected and stored by the front side inspector.
2. **Back Inspection Section:** Back portion of the product is inspected and the data of rework is collected and stored by the front side inspector.
3. **Final Inspection Section:** Final product is inspected and the dada of rework is collected and stored by the final inspector.

Three inspection lines are in a line and finally provide the finished goods like Figure 1

Figure 1: Production Line and Final Product

2.1.1 Production Line Working Flowchart

In garments production line, a product produced in three portions like front, back and combined (joint) or final section. Figure 2 shows the three portions of production line and their operations

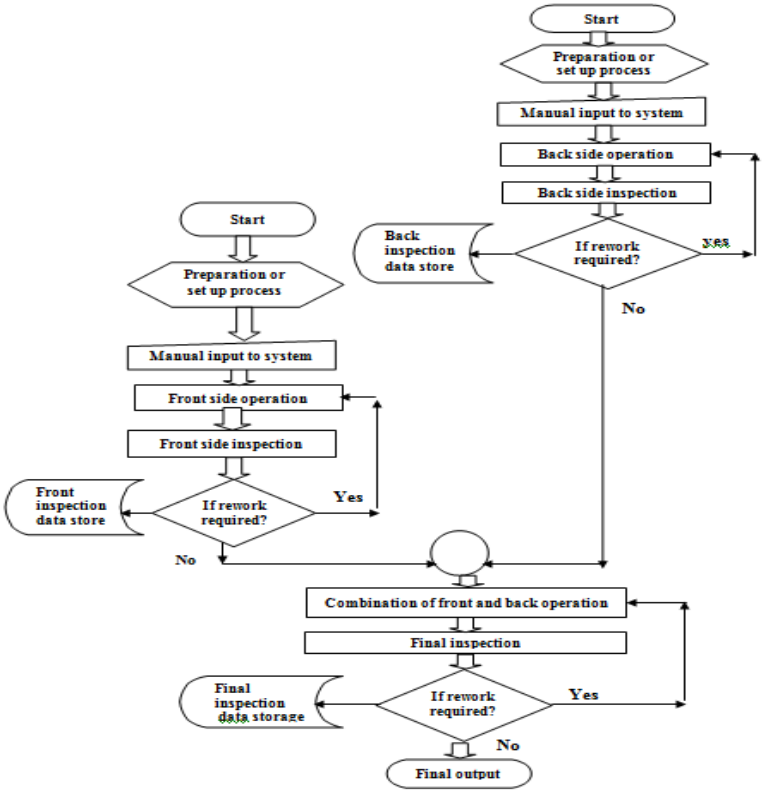
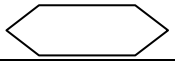
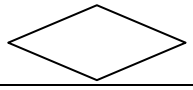
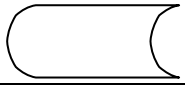
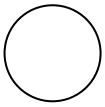


Figure 2: Production Line Working Flowchart

Above working flowchart, various symbols are used. Here symbol name and their meanings are represented by a table formation [19].

Table 1: Flow Chart Symbol and Their Meaning

Sl.	Symbol	Symbol name	Symbol description
01		Terminator (Terminal Point, Oval)	Terminators show the start and stop points in a process. When used as a Start symbol, terminators depict a *trigger action* that sets the process flow into motion.
02		Preparation	As the names states, any process step that is a Preparation process flow step, such as a set-up operation.

03		Manual Input	Manual Input flowchart shapes show process steps where the operator/ user is prompted for information that must be manually input into a system.
04		Process	Show a Process or action step. This is the most common symbol in both process flowcharts and business process maps.
05		Decision	Indicates a question or branch in the process flow. Typically, a Decision flowchart shape is used when there are 2 options (Yes/No, No/No-Go, etc.)
06		Stored Data	A general Data Storage flowchart shape used for any process step that stores data (as opposed to the more specific shapes to follow next in this table).
07		. Connector (Inspection)	The Connector Symbol represents the exit to, or entry from, another part of the same flowchart. It is usually used to break a flow line that will be continued elsewhere. It's a good idea to reference page numbers for easy location of connectors
09		Flow Line (Arrow, Connector)	Flow line connectors show the direction that the process flows.

Three individual section data are being collected and arranged in following table 2, 3, 4, 5, 6, 7 serially.

Table 2: Inspection Time at Back Inspection Section

Inspection Time at Back Inspection Section			
SL NO	Problem	Rework time (sec)	Avg. rework time (sec)
01	Flap ¼ stitch	51.53	1088.33/20
02	Front pocket dob stitch	31.06	= 54.4165
03	Down stitch	95.49	
04	Skip stitch	35.29	
05	Down stitch	54.35	
06	Skip stitch	20.19	
07	Tension loose	25.39	
08	Uneven stitch	113.39	
09	Brocken stitch	55.93	
10	Over stitch	43.89	
11	Open stitch	33.27	
12	Up down	39.41	
13	Flap ¼ stitch	49.38	
14	Uneven stitch	110.48	
15	Down stitch	78.25	
16	Tension loose	35.39	
17	Down stitch	87.48	
18	Skip stitch	32.17	
19	Over stitch	38.17	
20	Down stitch	57.82	

Table 3: Inspection on Back Section

Inspection on Back Section						
SL NO	Date	Time	No. Of rework	Avg. rework/hr	Avg. Rework time/pcs (sec)	Waste of time/hr (sec)
01	21-11-09	3.30-4.30pm	13	77/5	1088.33/20	54.4165*16
02	22-11-09	3.27-4.27pm	18	= 15.40	= 54.4165	= 870.664
03	22-11-09	01.00-02pm	15	(16)		
04	23-11-09	12.35-1.35pm	17			
05	23-11-09	3.30-4.30pm	14			

Table 4: Inspection Time at Front Inspection Section

Inspection Time at Front Inspection Section			
SL NO	Problem	Rework time (sec)	Avg. rework time (sec)
01	Down stitch	85.39	1263.62/20
02	Open stitch	38.93	= 63.181
03	Raw edge out	63.25	

04	Top stitch	130.56	
05	Uneven stitch	91.38	
06	Drop stitch	58.19	
07	Tension loose	37.75	
08	Down stitch	89.27	
09	Middle stitch	25.31	
10	Drop stitch	42.17	
11	Skip stitch	33.75	
12	Tension loose	40.27	
13	Open stitch	51.68	
14	Down stitch	67.13	
15	Uneven stitch	86.69	
16	Skip stitch	28.97	
17	Down stitch	75.27	
18	Top stitch	110.26	
19	Down stitch	68.17	
20	Tension loose	39.23	

Table 5: Inspection on Front Section

Inspection on Front Section						
SL NO	Date	Time	No. Of rework	Avg. rework/hr	Avg. Rework time/pcs(sec)	Waste of time/hr(sec)
01	21-11-09	3.30-4.30pm	6	33/5 = 6.6 (7)	1263.62/20 = 63.181	63.181*7 = 442.267
02	22-11-09	11am-12pm	8			
03	22-11-09	3.30-4.30pm	7			
04	23-11-09	12.35-1.35pm	7			
05	23-11-09	3.25-4.25pm	5			

Table 6: Inspection Time at Final Inspection Section

Inspection Time at Final Inspection Section			
SL NO	Problem	Rework time (sec)	Avg. rework time (sec)
01	Bartec	42.00	1007.95 = 50.3975
02	Bartec	48.00	
03	Middle stitch	93.63	
04	Bottom stitch	55.82	
05	Back stitch	75.03	
06	Tension loose	22.69	
07	Back stitch	40.16	
08	Lack of Back stitch	20.19	
09	Back stitch	23.41	
10	Back stitch	25.29	
11	Back stitch	75.49	
12	Back stitch	28.53	
13	Cut of back stitch	16.00	
14	Double stitch	25.49	
15	Uneven stitch	113.39	
16	Open stitch	45.78	
17	Mouth up down	115.45	
18	Bartec	57.29	
19	Skip stitch	25.18	
20	Bartec	59.13	

Table 7: Inspection on Final Section

Inspection on Final Section						
SL NO	Date	Time	No. Of rework	Avg. rework/hr	Avg. Rework time/pcs(sec)	Waste of time/hr(sec)
01	22-11-09	12.00-01.0pm	9	107/5 = 21.4 (22)	1007.95/20 = 50.3975	50.3975*22 = 1108.745
02	22-11-09	1.00-02.00pm	16			
03	22-11-09	03.00-4.00pm	32			
04	23-11-09	11am-12.0pm	37			
05	23-11-09	03.25-4.25pm	11			

2.1.2 Cause and Effect Diagram for Rework

A lot of causes are responsible for rework. All are not same responsible. From these some are known as main cause and some are sub causes shown on Figure 3

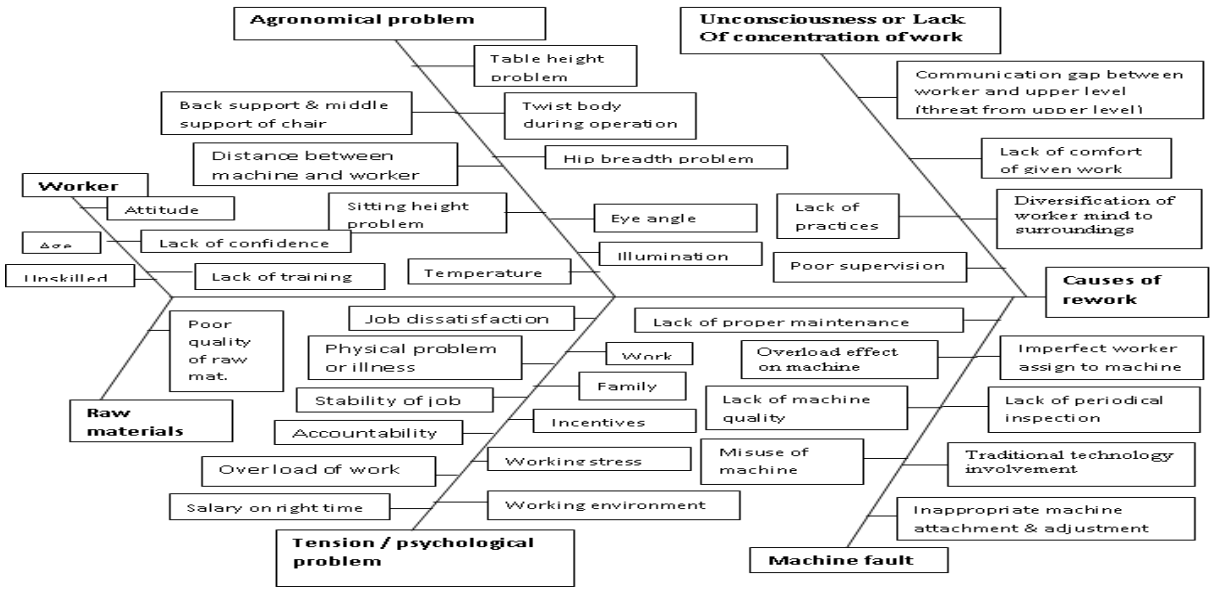


Figure 3: Cause-Effect Diagram of Over Processing or Rework

2.2 Excess Motion

Excess motion is the unnecessary motion where worker have to do his or her task, going outside of his or her working range.

2.2.1 Motion Calculation

A single production line is observed and finally following data are being found and that is shown on table 8.

Table 8: Worker Excess Motion Calculation

SL.NO	Worker name & ID NO.		Time with excess motion(sec)	Avg. (sec)	Time without excess motion (sec)	Avg. (sec)	Extra time taken (sec)	No. Of excess motion / day	Waste from motion/ day (sec)
01	Jasim	A	24.63	24.866	17.97	16.460	08.406	300	2521.80
		B	24.50		16.25				
	4979	C	25.47		15.16				
02	Rahima	A			17.44	16.150			
		B			15.75				
	2044	C			15.62				
03	Hasina	A			22.50	22.686			
		B			22.81				
	0419	C			22.75				
04	Rawson	A			17.15	16.550			
		B			15.93				
	3499	C			16.57				
05	Rozina	A	51.17	51.323	45.12	46.203	05.120	300	1536.00
		B	52.41		47.38				
	1816	C	50.39		46.11				
06	Urmi	A	51.37	51.370	46.12	46.676	05.054	300	1516.20
		B	52.19		47.13				
	4629	C	51.63		46.78				
07	Munni	A			38.97	38.840			
		B			37.25				
	0417	C			40.30				
08	Nargis	A	107.91	106.69	93.47	95.366	11.324	300	3397.20
		B	105.97		95.85				
	1771	C	106.19		96.78				
09	Hasem	A	42.78	40.240	38.17	35.003	05.237	300	1571.10

		B	36.82		33.13				
	4263	C	41.12		33.71				
10	Sohirul	A	54.92	53.393	41.73	41.070	12.323	300	3696.90
		B	52.19		40.38				
	0426	C	53.07		41.10				

SL.NO	Worker name & ID NO.		Time with excess motion(sec)	Avg. (sec)	Time without excess motion (sec)	Avg. (sec)	Extra time taken (sec)	No. Of excess motion / day	Waste from motion/ day (sec)
11	Maksuda	A			10.22	10.92			
		B			11.29				
	4544	C			11.25				
12	Hosne Ara	A	90.22	90.710	80.25	78.576	12.134	300	3640.20
		B	92.13		74.85				
	4552	C	89.78		80.63				
13	Sahana	A	47.54	47.776	37.28	38.390	09.386	300	2815.80
		B	48.16		39.18				
	0403	C	47.63		38.71				
14	Nazma	A	118.13	119.32	110.13	111.26	08.063	300	2418.90
		B	118.47		108.47				
	2683	C	121.38		115.19				
15	Rahima	A	37.13	39.00	36.12	37.520	01.486	300	445.80
		B	39.78		38.17				
	1900	C	40.11		38.27				
16	Afroza	A	45.53	42.816	39.10	39.010	03.806	300	1141.80
		B	40.13		39.16				
	4364	C	42.79		38.77				
17	Khadeza	A	41.40	40.503	25.78	25.523	14.980	300	4494.00
		B	40.29		25.23				
	4672	C	39.82		25.56				
18	Suma	A	82.06	81.950	65.66	65.050	16.900	300	5070.00
		B	82.47		62.31				
	1667	C	81.32		64.18				
19	Kalpona	A	36.37	36.800	32.22	31.983	04.817	300	1445.10
		B	37.15		31.06				
	4640	C	36.88		32.67				
20	Rozina	A			33.97	34.196			
		B			34.41				
	1647	C			34.21				

SL.NO	Worker name & ID NO.		Time with excess motion(sec)	Avg. (sec)	Time without excess motion (sec)	Avg. (sec)	Extra time taken (sec)	No. Of excess motion / day	Waste from motion/ day (sec)
21	Khadeza	A			33.87	34.060			
		B			33.98				
	1350	C			34.33				
22	Sahida	A	60.22	61.276	50.45	53.780	07.406	300	2221.80

		B	61.88		55.93				
	0429	C	61.73		55.23				
23	Iasmin	A	35.85	35.670	29.22	29.293	06.377	300	1913.10
		B	35.60		28.93				
	2103	C	35.56		29.73				
24	Ranu	A	78.47	77.590	65.30	66.240	11.350	300	3405.00
		B	76.38		66.47				
	4133	C	77.92		66.95				
25	Shopon	A	59.69	55.343	51.82	49.483	05.860	300	1758.00
		B	50.63		46.52				
	0835	C	55.71		50.11				
26	Maya	A	40.38	40.163	35.50	35.616	04.547	300	1364.10
		B	40.29		36.13				
	1845	C	39.82		35.22				
27	Moznu	A	49.15	48.816	45.31	44.590	04.226	300	1267.80
		B	48.72		44.17				
	2682	C	48.58		44.29				
28	Lucky	A	44.54	44.763	40.85	40.946	03.817	300	1145.10
		B	44.63		40.71				
	4052	C	45.12		41.28				
29	Soniya	A	61.85	61.513	57.12	56.833	04.680	300	1404.00
		B	60.12		56.28				
	1814	C	60.57		57.10				
30	Rawson	A	125.19	126.26	118.11	118.963	07.303	300	2190.90
		B	127.22		120.00				
	1025	C	126.39		118.78				

SL.NO	Worker name & ID NO.		Time with excess motion(sec)	Avg. (sec)	Time without excess motion (sec)	Avg. (sec)	Extra time taken (sec)	No. Of excess motion / day	Waste from motion/ day (sec)
31	Amena	A	33.31	31.339	30.19	26.830	04.506	300	1351.80
		B	29.91		24.83				
	0405	C	30.79		25.47				
32	Zahidur	A	26.90	27.966	21.59	24.126	03.840	300	1152.00
		B	28.59		25.91				
	3689	C	28.41		24.88				
33	Anisur	A	63.44	63.836	59.38	59.006	04.830	300	1449.00
		B	64.28		58.73				
	0411	C	63.79		58.91				
34	Lucky	A	43.91	44.243	40.53	40.343	03.900	300	1170.00
		B	44.45		40.39				
	1495	C	44.37		40.11				
35	Zohirul	A	34.59	33.916	32.58	31.603	02.313	300	693.90
		B	32.15		32.04				
	1774	C	34.63		30.19				

36	Taslima	A	15.97	14.890	09.68	10.596	04.294	300	1288.20
		B	13.95		11.82				
	5082	C	14.75		10.29				
37	Sanoar	A	17.92	17.216	12.78	11.700	05.516	300	1654.80
		B	16.15		10.59				
	4003	C	17.58		11.73				
38	Rabeya	A	48.15	47.886	42.75	42.620	05.266	300	1579.80
		B	47.39		42.48				
	4545	C	48.12		42.63				

Table 9: Total Waste from Excess Motion

Summary of waste from excess motion					
Observed worker 5 no production line	Waste occurred by no. of worker	Waste not occurred by no. of worker	Total waste of time / excess motion (at production line 5) in sec	Total waste of time for excess motion / day (at production line 5) in sec	Total waste of time for excess motion (total12 production line) in sec
38	31	07	209.067	209.067 * 300 = 62720.1	62720.1 * 12 = 752641.2

2.2.2 Causes and Effect Diagram of Excess Motion

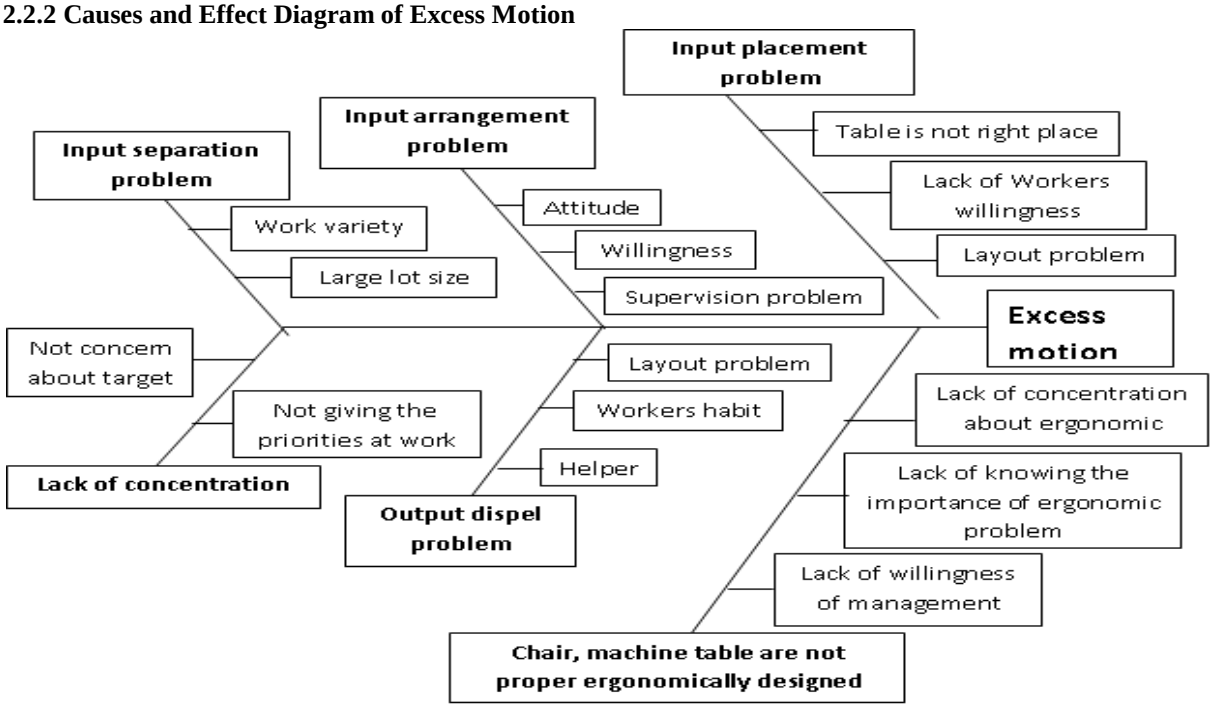


Figure 4: Cause and Effect Diagram of Excess Motion

2.2.3 Problem during Work Faced by Workers

It is clear that a lot of problems faced by worker and its affects also clear, is productivity decrease. Table 10 shows the problems faced by worker of RMG production floor. Figure 5 shown a bar chart of problems and number of worker faced those problems.

Table 10: Problem Occurred by Worker on Production Line 5

Problem during work (observed the production line 5)		
Sl.	Problem name	No of worker

01	Chair back and middle support problem.	38
02	Sitting range/ hip breadth problem.	38
03	Foot rest problem.	38
04	Inputs are out of workers working range/ inputs are not in right place.	24
05	Output dispel problem.	19
06	Twist body on input taking/output dispel.	15
07	Working table height problem.	13
08	Take a lot of time at input arrangement/ input arrangement problem.	11
09	Excess / unnecessary motion of worker.	10
10	Take lot of time at input separation / input separation problem.	10
11	Maximum works done by using one hand.	10
12	Excess movement of body.	9
13	Works with curving the body towards machine.	8
14	Take excess time at input taking/output dispel.	6
15	Do operation with twisting body.	5
16	Excess gap between machine and worker.	4
17	Long gap between machine and worker.	4
18	Sitting position fault/agronomical fault of chair.	4
19	Sitting height problem.	3

2.2.3 Histogram of Problem

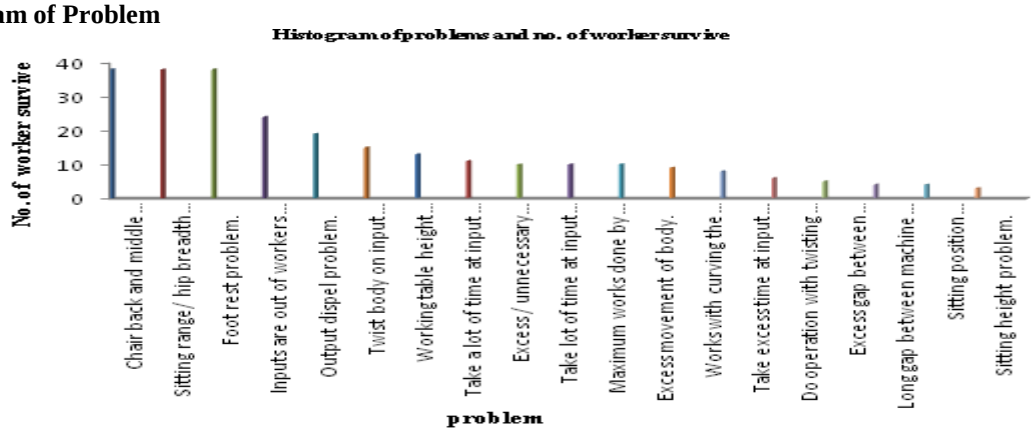


Figure 5: No. of worker survive from agronomical problem

2.3 Work in process inventory: (data are taken at 21.11.09)

Work in Process (WIP) Inventory is material between operations due to large lot production or processes with long cycle times.

Table 11: Waste from Work in Process Inventory

Sl.	Production line	Total input pcs.	Total output pcs	Work in process inventory	Std. production cycle time(min)	Output/day at std. cycle time (pcs)	Production cycle time (min)	Cycle Time difference (Min)	Output /day (pcs)
1	1	7386	6862	524	33	706	78.26	45.26	268
2	2	6520	6050	470	33	706	79.56	46.56	263
3	3	7210	5820	1390	28.2	835	47.87	19.67	471
4	4	6400	5890	510	23	1035	47.81	24.81	471
5	5	4519	3850	669	28.2	835	47.83	19.63	471
6	6	7400	5985	1415	28.2	835	47.88	19.68	471
7	7	770	0	770	14	1732	27.89	13.89	1055
8	8	8200	6670	1530	28.2	835	38.45	10.25	299
9	9	10180	9200	980	28.2	835	38.45	10.25	299
10	10	7259	6227	1032	28.2	835	67.59	39.39	319
11	11	10500	9100	1400	28.2	835	32.32	04.12	722
12	12	11050	9650	1400	28.2	835	32.32	04.12	722

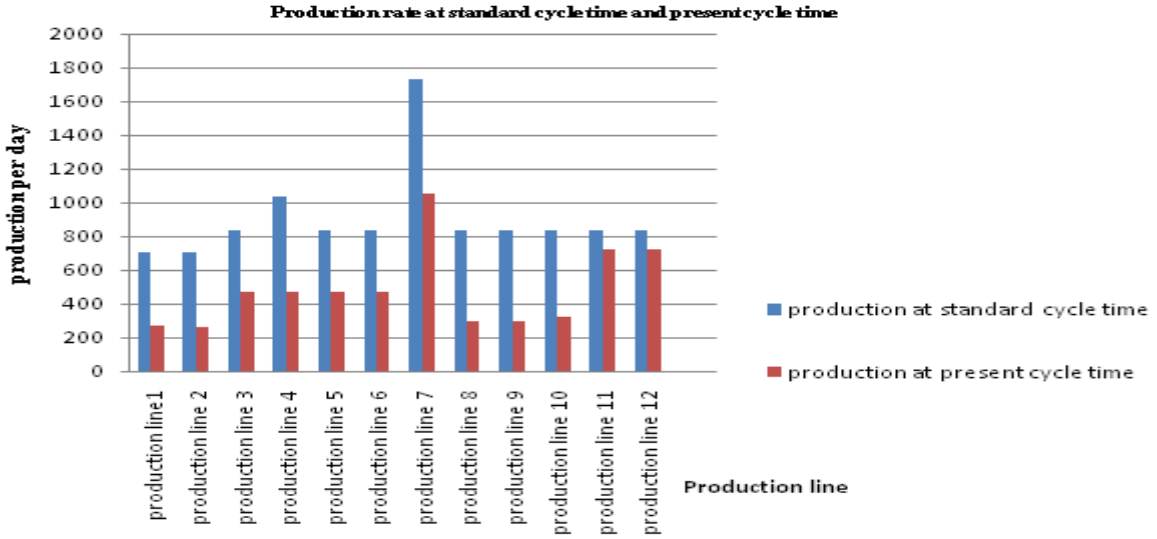


Figure 6: Difference between Production of Standard Cycle Time and Present Cycle Time

2.3.1 Cause-Effect Diagram of Work in Process Inventory:

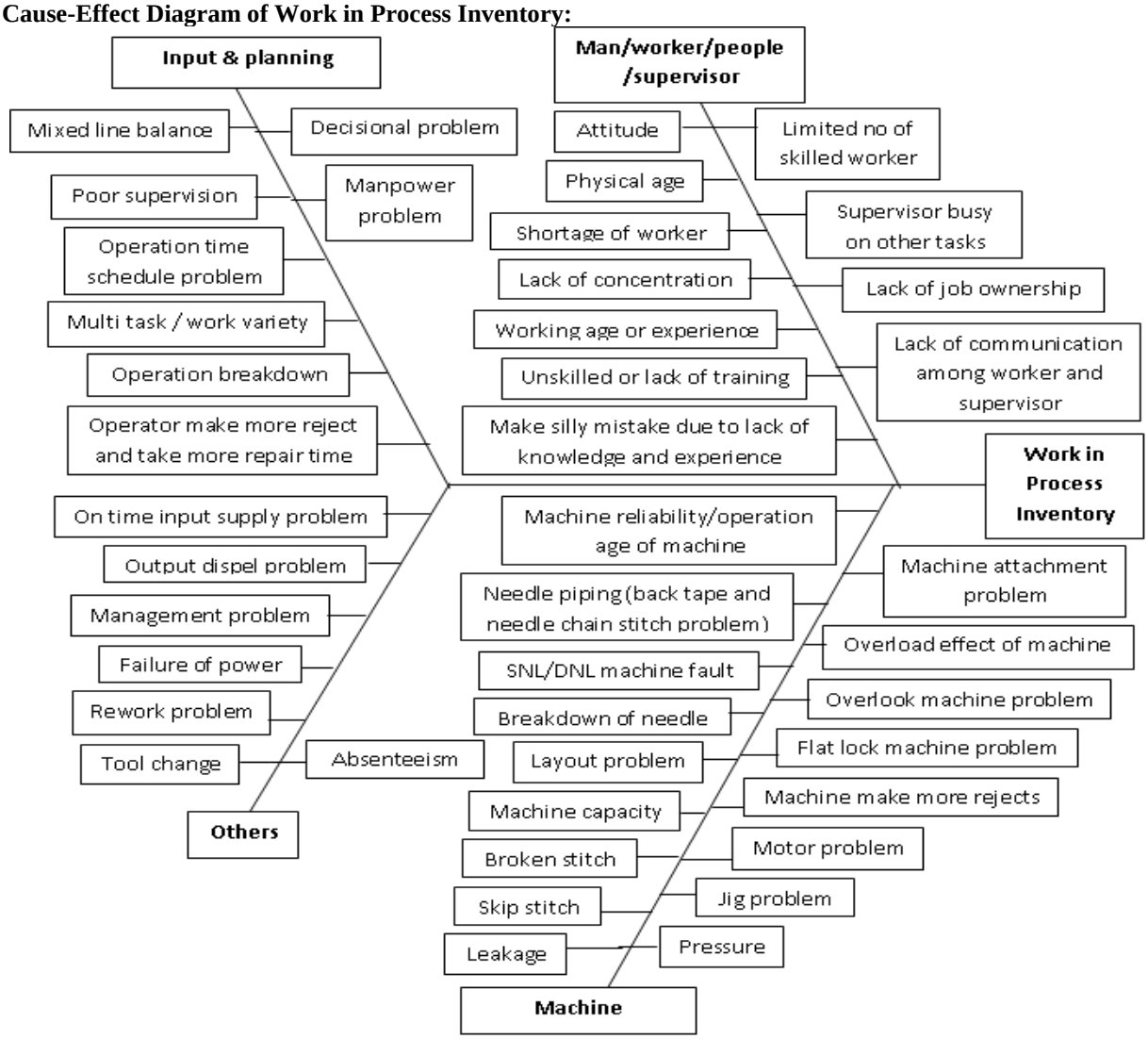


Figure 7: Cause and Effect Diagram of Work in Process Inventory

2.4 Transportation

Transportation is the movement of product that does not add value. This type of waste is a poorly conceived layout of the factory floor and storage facilities and long distance transportation and over handling of materials.

2.4.1 Existing Layout of Production Line 7

RACK

RHS LHS

1	Iron	27.75 sec Iron	TABLE	Iron	20.53 sec Iron	2
3	Loop make	5.00 F/L		Pocket rolling	19.84 SNL	4
5	Pocket decoration stitch	41.25 SNL		Pocket decoration stitch	31.09 SNL	6
7	Yoak join	32.19 O/L		Pocket decoration stitch/ bartec	16.16 BRTK	8
9	Yoak top stitch	20.75 F/A		Back rise	13.53 O/L	10
11	Match(pocket +body)	15.00 HW		Back rise top stitch	12.29 SNL	12
13	Back pocket join	39.97 SNL		Back pocket join	53.50 SNL	14
15	Back pocket ¼ top stitch	36.93 SNL		Back pocket ¼ top stitch	41.09 SNL	16
17	Back part(back +front join)	 INSPECTION		Loop tack/ number matching	25.00 SNL	18
19	Waist band contrast join	34.00 KANSAI		Loop join with number matching	6.19 SNL	20
21	Front pocket bag & facing join	18.00 SNL		Waist band contrast join	34.00 KANSAI	22
23	Pocket facing	18.00 VRT		Coin pocket over lock	3.15 3 OL	24
25	Pocket top stitch front	21.00 SNL		Single double fly tack	8.81 SNL	26
27	Pocket ¼ stitch side	20.63 SNL		1 pocket tack	21.70 SNL	28
29	Pocket bag close	23.53 3 OL		Front yoak over lock	18.40 5 OL	30
31	Pocket bag ¼ stitch	27.84 SNL		Single fly join/top stitch	15.96 SNL	32
33	Yoak top stitch	12.00 DNC		J stitch	18.24 SNL	34
35	Back rise	12.00 3 OL		Double fly join with body	18.96 SNL	36

37	Zipper attach	21.16 SNL		Inseam top stitch	18.69 F/A	38
39	Front rise close	17.25 SNL		Side seam over lock	18.31 5 OL	40
41	Inseam	24.65 5 OL		Waist band facing join	47.27 SNL	42
43	**Side seam**	**43.28** **5 OL**		Waist bend lower top ½ stitch	19.96 SNL	44
45	Side seam safety stitch	22.35 SNL		Waist bend upper top stitch	45.63 SNL	46
47	Side seam top stitch	27.19 SNL		Waist bend upper top stitch	43.13 SNL	48
49	Waist bend facing join	46.38 SNL		Waist bend tack	54.36 SNL	50
51	Patch join with button hole	13.15 BH		Waist bend lower top stitch	56.84 SNL	52
53	Button attach	12.37 BH		Waist bend mouth close	22.00 SNL	54

55	Level join	19.59		Waist bend mouth close	31.40	56
		SNL			SNL	
57	Waist bend tack	35.90		Loop join	31.85	58
		SNL			SNL	
59	Waist bend upper top stitch	40.50		Hem rolling	36.54	60
		SNL			DNL	
61	Level tack	10.00		Pocket corner bartec	26.38	62
		SNL			BRTK	
63	Loop tack	30.00		Hem rolling	41.60	64
		SNL			DNL	
65	Loop bartec	37.79				
		BRTK				

2.4.2 Transportation Time at Existing Layout of Production Line 7

Table 12: Transportation Time at Existing Layout of Production Line 7

Destination	Sl.	Go (sec)	Come(sec)	Total(sec)	Avg.(sec)
Rack to table 7	1	8.65	8.40	17.05	16.30
	2	7.44	8.41	15.85	
	2	8.32	7.68	16.00	
Table 1&2 to table 14	1	11.68	13.18	24.86	24.57
	2	12.53	12.19	24.72	
	3	11.83	12.32	24.15	
Table 3 to table 18	1	17.12	17.72	34.84	35.49
	2	18.25	18.38	36.63	
	3	18.13	16.87	35.00	
Table 17 to table 43	1	21.19	19.50	40.69	40.54
	2	20.21	20.56	40.77	
	3	19.39	20.78	40.17	
Table 18 to table 64	1	32.62	32.44	65.06	63.77
	2	31.52	32.14	63.66	
	3	33.12	29.47	62.59	
Table 19 to table 51&52	1	25.46	26.12	51.58	51.68
	2	26.25	25.31	51.56	
	3	25.12	26.79	51.91	

2.4.3 Production Line 7 after Changing Existing Layout

RACK

RHS LHS

1	Iron	27.75	TABLE	Iron	20.53	2
		Iron			Iron	
3	back pocket rolling	19.84		Pocket decoration stitch	24.11	4
		SNL			SNL	
5	Pocket decoration stitch	24.11		Pocket decoration stitch	24.11	6
		SNL			SNL	
7	Yoak join and back rise	22.86		Yoak join and back rise	22.86	8
		5 OL			5 OL	
9	Yoak top stitch	20.75		Back rise top stitch, match pocket & body	27.29	10
		F/A			SNL	
11	Back pocket join	31.15		Back pocket join	31.15	12
		SNL			SNL	
13	Back pocket join	31.15		Back pocket ¼ top stitch	26.00	14
		SNL			SNL	
15	Back pocket ¼ top stitch	26.00		Back pocket ¼ top stitch	26.00	16
		SNL			SNL	
17	Coin pocket, pocket facing, single fly, double fly, over lock	13.15		Front pocket bag & facing join, double fly join	26.81	18
		3 OL			SNL	
19	Pocket facing attach	18.00		Pocket top stitch	21.00	20
		VRT			SNL	

21	Pocket tack	21.70		Pocket tack	21.70	22
		SNL			SNL	
23	Pocket ¼ stitch	20.63		Pocket bag close	23.53	24
		SNL			3 OL	
25	Pocket bag ¼ stitch	27.84		Front yoak over lock	18.40	26
		SNL			5 OL	
27	Single fly join & top stitch	15.96		J top stitch mark and do	18.24	28
		SNL			SNL	
29	Yoak top stitch	12.00		Double fly join with body, zipper attach, front rise close	28.70	30
		DNC			SNL	
31	Double fly join with body, zipper attach, front rise close	28.70		Inseam & side seam	22.64	32
		SNL			5 OL	
33	Inseam & side seam	22.64		Inseam & side seam	22.64	34
		5 OL			5 OL	
35	Inseam top stitch	18.69		Side seam safety stitch	22.35	36
		F/A			SNL	
37	Side seam top stitch	27.19		Waist band and contrast join	22.60	38
		SNL			KANSAI	
39	Waist band and contrast join	22.60		Waist band and contrast join	22.60	40
		KANSAI			KANSAI	
41	Waist bend join	31.27		Waist bend join	31.27	42
		SNL			SNL	
43	Waist bend join	31.27		Patch join with button & button attach	25.52	44
		SNL			BH	
45	Main level tack & size level tack	29.59		Waist band upper top stitch & waist bend tack	31.36	46
		SNL			SNL	
47	Waist band upper top stitch & waist bend tack	31.36		Waist band upper top stitch & waist bend tack	31.36	48
		SNL			SNL	
49	Waist band upper top stitch & waist bend tack	31.36		Waist band upper top stitch & waist bend tack	31.36	50
		SNL			SNL	
51	Waist band upper top stitch & waist bend tack	31.36		Waist bend lower top stitch	25.60	52
		SNL			SNL	
53	Waist bend lower top stitch	25.60		Waist bend lower top stitch	25.60	54
		SNL			SNL	
55	Waist band mouth close	26.70		Waist band mouth close	26.70	56
		SNL			SNL	
57	Make w/b loop	05.00		Hem rolling	19.14	58
		FL			DNL	
59	Hem rolling	32.00		Hem rolling	32.00	60
		DNL			DNL	
61	Loop tack upper	30.00		**Loop attach lower**	**31.85**	62
		SNL			**SNL**	
63	Bar tack loop & pocket corner	32.08		Bar tack loop & pocket corner	32.08	64
		BRTK			BRTK	
65	Pocket decoration stitch/bar tack	16.16				
		BRTK				

2.4.4 Transportation time after changing layout of production line 7

Table 13: Transportation time after changing layout of production line 7

Destination	Sl.	Go(sec)	Come(sec)	Total(sec)	Avg.(sec)
Rack to table 7	1	8.65	8.40	17.05	16.30
	2	7.44	8.41	15.85	
	3	8.32	7.68	16.00	
Table 1&2 to table 11	1	9.68	9.63	19.31	19.79
	2	10.29	10.11	20.40	
	3	9.79	9.88	19.67	
Table 61 to table 62	1	1.11	1.05	2.16	2.22
	2	1.21	1.07	2.28	

	3	1.10	1.13	2.23	
Table 16 to table 32	1	12.92	12.56	25.48	24.66
	2	12.56	11.87	24.43	
	3	12.34	11.75	24.09	
Table 57 to table 61	1	2.78	2.88	5.66	5.64
	2	2.86	2.63	5.49	
	3	2.92	2.86	5.78	
Table 38 to table 52	1	10.80	10.85	21.65	21.64
	2	10.92	10.72	21.64	
	3	10.75	10.88	21.63	

2.5 Waiting

Waiting is a non value added activity. Waiting for materials, tools, information, equipment, etc., this may be a result of poor planning, late supplier deliveries, lack of communication, over booking of equipment etc. for example

Table 14: data of product waiting time on production line

1.Pocket facing iron					
Product NO.	Processing time (sec)	Waiting time (sec)	Cumulative waiting time(sec)	Avg. waiting time(sec)	Avg. lot transfer per day
01	16.44	207.71	1657.35	110.49.13	32
02	12.31	195.40			
03	10.21	185.19			
04	14.00	171.19			
05	14.19	157.00			
06	14.31	142.69			
07	13.72	128.97			
08	14.75	114.22			
09	15.03	99.19			
10	16.16	83.03			
11	16.78	66.25			
12	14.66	51.59			
13	15.93	35.66			
14	16.38	19.28			
15	19.28	0.00			

2.Pocket facing iron					
Product NO.	Processing time (sec)	Waiting time (sec)	Cumulative waiting time(sec)	Avg. waiting time(sec)	Avg. lot transfer per day
01	14.00	209.07	1561.98	104.132	32
02	14.34	194.73			
03	14.78	179.95			
04	13.75	166.20			
05	17.13	149.07			
06	17.54	131.53			
07	14.75	116.78			
08	13.50	103.28			
09	14.75	88.53			
10	14.62	73.91			
11	12.84	61.07			
12	16.38	44.69			
13	15.65	29.04			
14	14.91	14.13			
15	14.13	0.00			

3.Coin pocket, back pocket & side pocket rolling					
Product NO.	Processing time (sec)	Waiting time (sec)	Cumulative waiting time(sec)	Avg. waiting time(sec)	Avg. lot transfer per day
01	36.47	509.52	3732.51	248.834	32
02	38.66	470.86			
03	39.03	431.83			

04	40.47	391.36			
05	38.10	353.26			
06	37.89	315.39			
07	39.19	276.20			
08	30.75	245.45			
09	35.12	210.33			
10	33.91	176.42			
11	34.26	142.16			
12	38.57	103.59			
13	30.00	73.59			
14	41.04	32.55			
15	32.55	0.00			

4.Back pocket position mark					
Product NO.	Processing time (sec)	Waiting time (sec)	Cumulative waiting time(sec)	Avg. waiting time(sec)	Avg. lot transfer per day
01	07.34	119.58	878.95	58.5966	32
02	10.59	109.01			
03	08.29	100.72			
04	07.53	93.19			
05	10.38	82.81			
06	08.56	74.25			
07	07.53	66.72			
08	08.29	58.43			
09	08.53	49.90			
10	08.12	41.78			
11	07.79	33.99			
12	09.31	24.68			
13	08.67	16.01			
14	08.13	07.88			
15	07.88	0.00			

III. WASTE REDUCTION SOLUTIONS

Every problem should have minimum a solution. Waste that was found in this research work can be solved by using some rules and regulations and implement them. This section emphasis on reducing or removing Overproduction, excess motion, work in process inventory, transportation and waiting etc. wastes from the production floor of the selected industry.

3.1 Points of reducing waste from over processing

a) Create concentration on work by reducing communication gap between worker and supervisor
b) Proper distribution of work among worker
c) Increase training facilities
d) Workplace and work station must be designed ergonomically
e) Increase worker attitude, leadership, skill development, confidence by proper training facilities
f) A proper on-time maintenance system should be provided for various sewing machines so that it is possible to minimize machine breakdown.

3.2 Points of reducing waste from excess motion

a) Develop opportunities to receive inputs and dispel outputs by using both hands equal contribution.
b) Work table height must be adjustable of each worker.
c) Sitting chair must be adjustable of each worker with respect to table.
d) Chair must be designed ergonomically, giving major concern Back support, Middle support, Hip breadth etc. Input must be placed not only the workers limited range but also proper place within the range.
e) Inputs, provided from previous table should have to be arranged.
f) Workers have to be conscious about agronomical problem and its disadvantages by providing them proper training.
g) Workers have to be concentrated about their responsibilities.
h) Worker and working table distance should be appropriate with respect to individuals.

3.3 Points of reducing waste from work in process inventory

a) Change workers negative attitude
b) Change the worker absenteeism
c) Trained up worker and increase their skill

d) Worker should be registered age limit
e) Every supervisor should give concentration on their specific task
f) Develop good communication among worker and above
g) Increase worker knowledge and experience
h) Working machine should have reliable
i) Tool change should be quick
j) Machine, needle, jig and other accessories should have well attached
k) Ensure continuous power supply
l) Machine layout should be proper
m) Avoid machine those are responsible for production of reject or scrap product
n) Output of production line should be reliable
o) Develop mentality among worker
p) Management should be strong.
q) Decision should have right and quick
r) Organization should have proper/available manpower

3.4 Points of reducing waste from transportation

- Production line layout should be proper
- The line supervisor must monitor his/her line properly to ensure that no operators, helpers make delay in his/her operation without any reason. They should keep production in the right direction by motivating the workers.

3.5 Points of reducing waste from waiting

- Increase machine and worker parallel.
- Reduce lines input lot size

IV. RESULTS AND IMPACT

4.1 Calculation of Waste

This section is only represents the amount of waste from over processing, excess motion, work in process inventory, transportation and waiting.

4.1.1 Over Processing

From Table 2,
Waste of time from rework on back inspection table per day
= average no. of alter per hour * 8 * average rework time (sec) = 16 * 8 * 54.4165 sec = 6965.312 sec.
From Table 4,
Waste of time from rework on front inspection table per day
= average no. of alter per hour * 8 * average rework time (sec) = 7 * 8 * 63.181 sec = 3538.136 sec.
From Table 6,
Waste of time from rework on final inspection table per day
= average no. of alter per hour * 8 * average rework time (sec) = 22 * 8 * 50.3975 sec = 8869.96 sec.
Total waste from over-processing of a single production line per day,
= (Waste of time from rework on back inspection table per day) + (Waste of time from rework on front inspection table per day) + (Waste of time from rework on final inspection table per day) = 6965.312 sec + 3538.136 sec + 8869.96 sec = 19373.408 sec = 322.89 min = 5.3815 hrs
So, total waste from over-processing on twelve production lines per day,
= 5.3815 hrs * 12 lines = 64.578 hrs

4.1.2 Results of Waste from Excess Motion

Table 15 shows the total waste of time from excess motion in the same time how many and what percentages of worker are responsible for excess motion of a single production line shown in Figure 8.

Table 15: Waste from Excess Motion of Production Line 5

Summary of Waste from Excess Motion					
Observed Worker (Prod'n Line-5)	Waste Occurred by No. of Worker	Waste not Occurred by No. of Worker	Total Waste of Time / Excess Motion (at Production Line 5) in sec	Total Waste of Time for Excess Motion / Day (at Production Line-5) in sec	Total Waste of Time for Excess Motion (Total 12 Production Line) in sec
38	31	07	209.067	209.067 * 300 = 62720.1	62720.1 * 12 = 752641.2

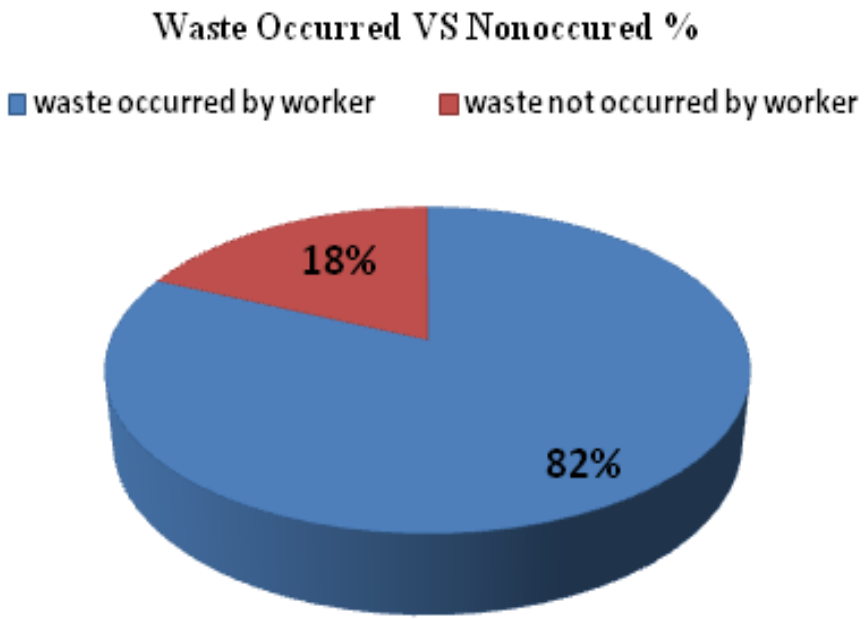


Figure 8: Waste Occurred vs. Not Occurred % of Worker

4.1.3 Work in Process Inventory

Waste of work in process inventory is calculated first from production line 1.Table 16 shows the total waste of time of 12 production lines of selected RMG companies production floor. Table 17 shows the output difference of standard cycle time and existing or current cycle time.

- Assume efficiency 80 %.
- 65 worker works in each line.

$$\text{Line Output per Day} = \frac{\text{Working Time per Day (in Sec)} - \text{Cycle Time}}{\frac{\text{Pitch time}}{\text{Efficiency}}} + 1$$

$$\text{Pitch Time} = \frac{\text{Cycle time (sec)}}{\text{No of operator}}$$

$$\text{Existing Line 1 Output per Day} = \frac{(8 * 3600) - 78.26 * 60}{\frac{72.24}{0.80}} + 1 = 268 \text{ Pcs}$$

$$\text{Standard Output of Production Line 1 per Day} = \frac{(8*3600) - 33*60}{\frac{30.4615}{0.80}} + 1 = 706 \text{ Pcs}$$

Table 16: Waste Calculation from Work in Process Inventory

Sl.	Prod'n Line	Production at Std. cycle time/day	Production at Present Cycle Time/Day	Loss of Prod'n/ Day(Pcs)	Waste of Time from Work in Process Inventory/Day (sec)	Total Waste from Twelve Production Line /Day
01	1	706	268	438	17867.422	163120.892 sec = 2718.6815 min = 45.3113 hrs
02	2	706	263	443	18071.388	
03	3	835	471	364	12554.730	
04	4	1035	471	564	15693.913	
05	5	835	471	364	12554.730	
06	6	835	471	364	12554.730	
07	7	1732	1055	677	11257.274	
08	8	835	299	536	18487.185	
09	9	835	299	536	18487.185	
10	10	835	319	516	17797.365	
11	11	835	722	113	3897.485	
12	12	835	722	113	3897.485	

Table 17: Difference between Production of Standard Cycle Time and Present Cycle Time

Sl.	Production Line	Production of standard cycle time / day	Production of present cycle time / day
01	1	706	268

02	2	706	263
03	3	835	471
04	4	1035	471
05	5	835	471
06	6	835	471
07	7	1732	1055
08	8	835	299
09	9	835	299
10	10	835	319
11	11	835	722
12	12	835	722

4.1.4 Transportation

Transportation is the important factor of any production system. Table 18 shows the amount of waste of time from transportation.

Table 18: Waste Calculation from Transportation

Transportation on Existing Layout (Prod'n Line-7)	Transportation on New Layout (Production Line-7)	Transportation Time on Existing Layout (Prod'n Line-7) (sec)	Transportation Time on New Layout (Prod'n Line-7) (sec)	Waste (Time) per/ Transportation (sec)	No. of Transportation per Day
Rack to table 7	Rack to table 7	16.30	16.30	0.00	100
Table 1&2 to table 14	Table 1&2 to table 11	24.57	19.79	4.78	100
Table 3 to table 18	Table 61 to table 62	35.49	2.22	33.27	100
Table 17 to table 43	Table 16 to table 32	40.54	24.66	15.88	100
Table 18 to table 64	Table 57 to table 61	63.77	5.64	58.13	100
Table 19 to table 51&52	Table 38 to table 52	51.68	21.64	30.04	100

Transportation on Existing Layout (Prod'n Line-7)	Transportation on New Layout (Production Line-7)	Waste (Time) per/ Transportation (sec)	No. of Transportation per Day	Total Waste Time (Prod'n Line-7) in Sec	Total Waste Time from transportation (12 prod'n line) in sec
Rack to table 7	Rack to table 7	0.00	100	0.00	12410 * 12 = 170520
Table 1&2 to table 14	Table 1&2 to table 11	4.78	100	478	
Table 3 to table 18	Table 61 to table 62	33.27	100	3327	
Table 17 to table 43	Table 16 to table 32	15.88	100	1588	
Table 18 to table 64	Table 57 to table 61	58.13	100	5813	
Table 19 to table 51&52	Table 38 to table 52	30.04	100	3004	

Existing Layout of Production Line, Efficiency:

$$= \frac{\frac{\text{Standard cycle time}}{\text{No. of operator}}}{\text{Bottle neck process time}} = \frac{\frac{1673.80 \text{ sec}}{65}}{43.28 \text{ sec}} = 59.498\ \%$$

New Layout of Production Line, Efficiency:

$$= \frac{\frac{\text{Standard cycle time}}{\text{No. of operator}}}{\text{Bottle neck process time}} = \frac{\frac{1623.56 \text{ sec}}{65}}{31.85 \text{ sec}} = 78.423\ \%$$

4.1.5 Waiting

Waiting times are calculated as total waste of time per day per production line and it is shown on Table 19.

Table 19: Waste Calculation of Waiting per Day per Production Line

Sl.	Operation Name	Cumulative Waiting Time(sec)	Avg. Lot Transfer per Day per Line	Total Waste of Time per Day per Line
01	Pocket facing iron	1657.35	32	(191419.01*32) sec =6125408.32 sec =1701.5023 hr =70.8959 day
02	Pocket facing iron	1561.98		
03	Coin pocket, back pocket & side pocket rolling	3732.51		
04	Back pocket position mark	878.95		
05	Back panel join	1275.87		
-	-	-		
-	-	-		
-	-	-		
-	-	-		
-	-	-		
46	Flap mark	855.20		
47	Pocket rolling	739.30		
48	Tap join top stitch	5393.96		
49	Pre inspection	11464.70		
50	Button attach	655.21		

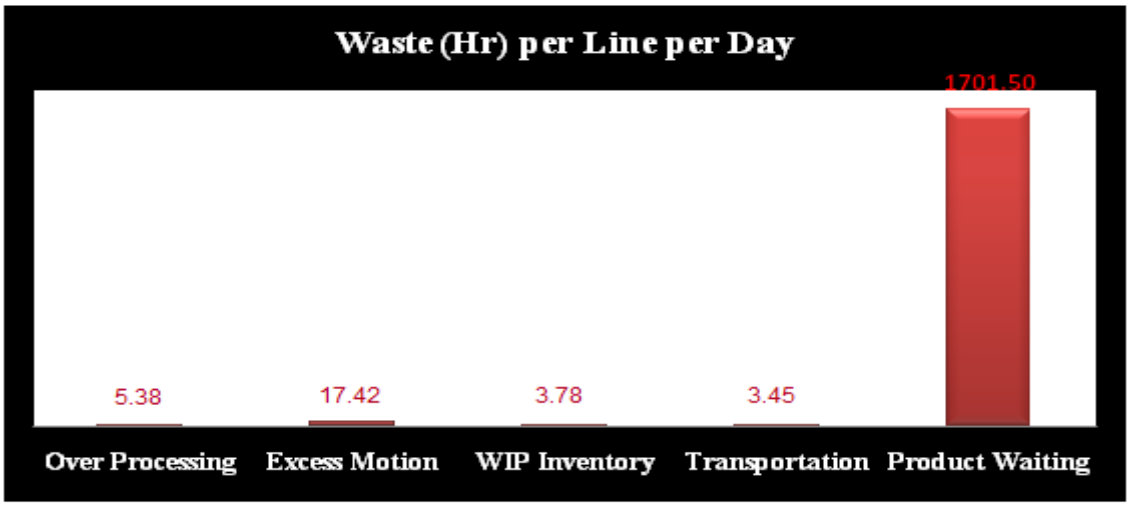


Figure 9: Waste (Hr) Per Line per Day

V. Conclusion

This research has focused mainly on waste of sewing section of production floor. Average 65 worker works at every production line. From waste analysis, it has been found that 5.3815 hrs waste per day only from over processing, 17.42225 hrs per day from excess motion, 3.7759 hrs per day from work in process inventory, 3.4472 hrs per day from transportation of a single production line respectively which signifies that a lot of time is being wasted due to over processing, excess motion, work in process inventory, transportation and so on. In this research work illustrates that man is much more responsible for the major portion of this waste. It is also clear that waste is being created due to absence of expert personnel, in sufficient guidelines, lack of proper training, carelessness about won task, lack of realization that it is his or her organization, tools and accessories etc. on the industry that we works for research purpose by eliminating transportation waste, line efficiency will be increase from 59.498 % to 78.423 %.

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